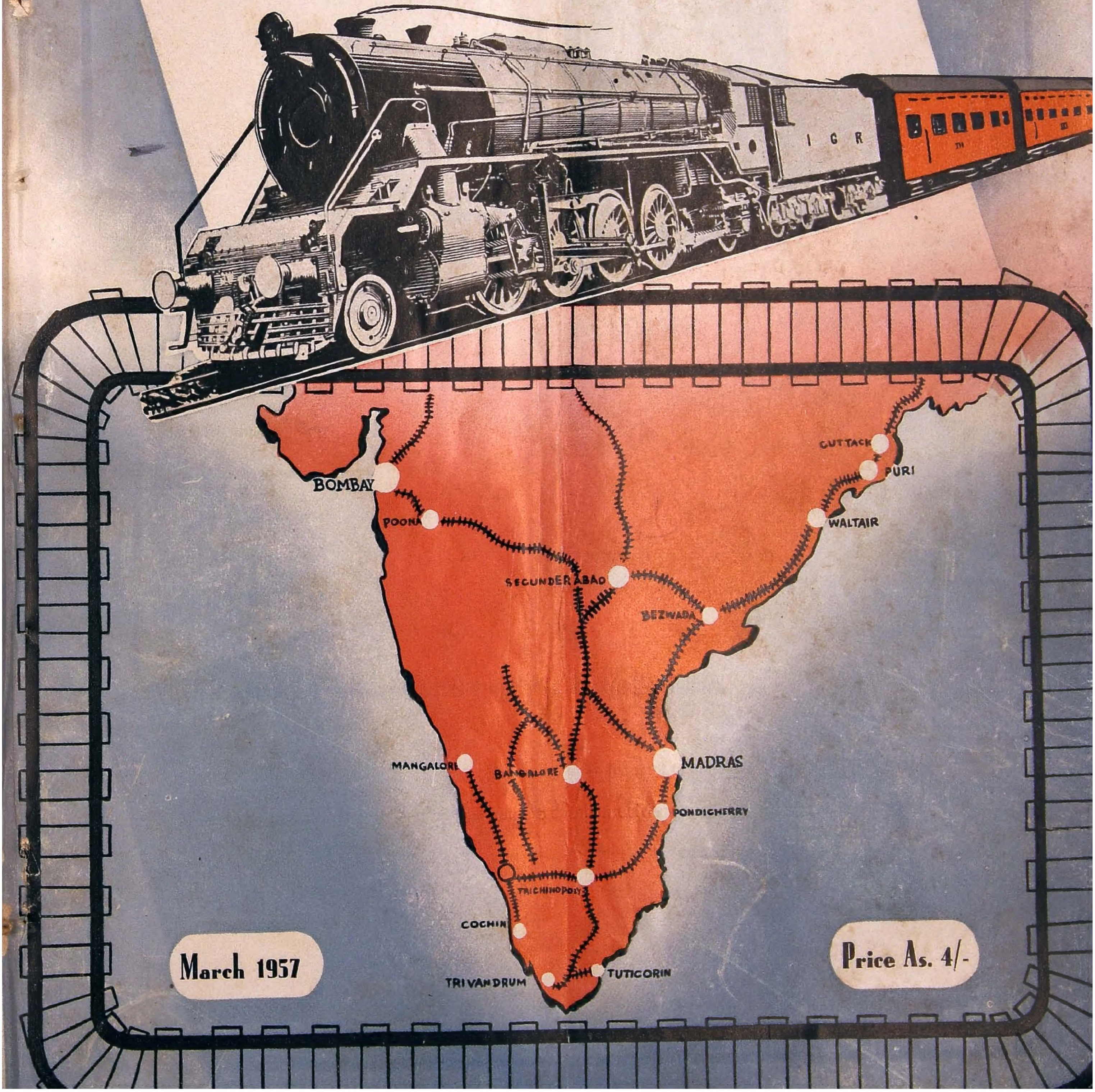
SOUTHERN RAILWAYS *Magazine*



March 1957

Price As. 4/-

Prime Minister Addresses General Managers

SHRI Jawaharlal Nehru, Prime Minister of India addressed General Managers of Railways in New Delhi on January 11, 1957. Present at the meeting were the Union Minister for Railways and Transport Shri Jagjiwan Ram, the Deputy Railway Minister, Shri O. V. Alagesan, Chairman and Members of the Railway Board and General Managers and Chief Engineers of the various Railways.

It was for the railways to decide what they would do with the limited funds available to them during the second Plan period, the Prime Minister said. But there should obviously be an order of priorities, and the general attitude should be to spend money more on productive work. For instance, he said, it was no good trying to run trains faster in order to save some time; It was important that more trains should be run and regularly.

For the growth of the railways, like that of any other sector of the country's economy, it was necessary to raise our standards of technical training and personnel and to build up a strong industrial background, so that we could ourselves manufacture the things we required and gradually build up our technical know-how and steadily advance in technical knowledge.

The Prime Minister Said: "The railways have a long history of over 100 years behind them. They are doing a fine job of work. These accidents are unfortunate. While you should take all possible precautions, you should not be downhearted".

The railways were the life blood of the nation and a very important distributive service he added. It was necessary for their successfull working to give the railway staff the psychological feeling of their being engaged in a vast undertaking. A railway worker's individual job may be small, but he should be made to feel that he is helping to perform part of a huge job.

Since the railways dealt with large numbers of people daily, it was also important that steps should be taken to secure the co-operation of the travelling public. The Indian railways should build up through proper training of staff a reputation for courtesy, co-operation and goodwill.

The Prime Minister in this connection said that it was an anomaly that people in this country were personally very clean, but socially most unclean. This was evident on railway premises and in the trains. The railways should, therefore, undertake educative propaganda to create consciousness in the travelling public and thus raise the standard of cleanliness.

* * *

NATIONAL RAILWAY USERS' CONSULTATIVE COUNCIL

Shri Jagjivan Ram, Union Minister for Railways and Transport, inaugurated the sixth meeting of the National Railway User's Consultative Council in New Delhi on January 10, 1957. The union Deputy Ministers for Railways & Transport, Shri O. V. Alagesan and Shri Shah Nawaz Khan were present at the Conference. The other Counsil Members who attended the meeting included representatives of various trade and industrial interests, Railway Zonal Constructive Committees, Central Government Ministers and Members of the Railway Board.

Addressing the Council at the outset, Shri Jagjivan Ram touched briefly on certain outstanding features of operation on the railways. During the period April-October 1956, there had been an increase in loading to the extent of 6.1 per cent on broad gauge and 9.3 per cent on metre gauge, as compared to the corresponding period of the previous year, he stated. This resulted in a sharp decline in outstanding demands for wagons. This substantial achievement became possible as a result of constant chasing and various other measures for stepping up the throughput of wagons.

There had also been a steady improvement recorded in respect of "wagon miles per wagon day" a reliable guide to the operational efficiency of a railway system, the Railway Minister added. On the Broad Gauge system, which shouldered the burden of about 80 per cent of the total traffic, this index advanced from 45.9 in October 1955 to 49.9 in the same month in 1956, an improvement of nearly nine per cent in one year. The October 1956 index was, in fact, the highest to be achieved exceeding even the best wartime performance. A similar improvement took place on the metre gauge system, the index during the same period advancing from 29.3 to 32.2.

Referring to passenger transport, overcrowding was admittedly serious on some sections, Shri Jagjivan Ram stated. Railways had nevertheless expanded somewhat the passenger transport capacity, which reached 189,800 train miles on the Broad Gauge and 117,100 train miles on the Metre Gauge on December 1, 1956 as compared with 183,300 on Broad Gauge and 115,800 on Metre Gauge on April 1, 1956.

The overall picture of the provision in the second Plan for the removal of overcrowding was, however, not bright. The plan allowed only for 15 per cent additional passenger services, which might not be adequated to keep pace even with the growth of population during the period and the stimulation of travel which would result from the increased economic activity in the country.

The third class sleeper coaches, wherever these were now running, had a three-tier arrangement. It was proposed to try out an experiment with six sleeper coaches on the broad gauge and six on the metre gauge having two-tier arrangement, the Minister announced.

A minimum scale of basic amenities at train halts provided for the convenience of small wayside villages and rural population had now been prescribed. A number of the recommendations of the Estimates Committee of Parliament regarding provision of additional passenger amenities had been accepted. Among these were extension of reservation facilities for third class passengers, provision of more left luggage offices, lockers, and wash and brush up facilities at certain stations and provision of separate enquiry counters for telephonic enquiries.

The question of increasing basic amenities particularly those travelling in Class III, would receive close attention though for the next few years more emphasis might be placed on providing adequate accommodation for Class III passengers. Schemes for 'Prestige' buildings were being pruned and the money so saved would be diverted to more useful forms of railway development.

Continuing his address Shri Jagjivan Ram stated that railway administrations had launched campaigns of social education through the medium of posters, loudspeakers, films etc., with a view primarily to creating in the minds of passengers a greater awareness of their rights and responsibilities and to encourage a more intelligent use of the amenities on the railways. A comprehensive scheme for a more effective drive was under consideration.

Considerable reorganisation in railway catering services had already been undertaken, following the recommendation of the High Power Committee on Catering and in the last few months departmental catering had been introduced at Victoria Terminus, Poona and Ooty. Departmental working of a number of restaurants and dining cars on the railways had also been taken over.

Introduction of the Full Divisional System had now been completed on the Southern, Central and Western Railways and was expected to be completed by August this year on the North Eastern Railway. Thereafter the comparatively small South Eastern Railway would be taken up for divisionalisation.

The events of the past few months connected with the two major accidents which had unfortunately resulted in heavy casualties were matters of great concern, Shri Jagjivan Ram said. The Railway Board and the Railways were in no way complacent about the importance of taking all precautions open to man to prevent such tragic occurrences. A conference of the General Managers of the Zonal Railways had been convened in order to discuss this matter fully preparatory to taking further effective steps. It should be appreciated, however, that the standard of safety in passenger travel on the Indian Railways did not at all compare unfavourably with that in other far more advanced countries. The ratio of fatalities and injuries per hundred million originating passengers on the U. S. Railways during 1951–54, averaged 156, on the British Railways it averaged 48, and on the Indian railways the figure was 32, Shri Jagjivan Ram added.

The two-day long deliberations of the Council then began. Matters pertaining to the transportation of goods on Indian Railways figured prominently during the discussions. Other subjects discussed pertained to passenger amenities, catering, ticketless travel, claims, etc.

Members generally expressed their appreciation of the steady improvement achieved in the transportation position, and noted appreciatively the recent higher loadings and better wagon utilisation. The Council was assured that various suggestions made by members during discussion for achieving further improvements, would be carefully looked into by the Railway Board.

Individual difficulties experienced by certain sections of trade and industry were mentioned by some members and particular reference was in this connection made to certain sections of the North Eastern Railway. The Council was informed that several schemes were now

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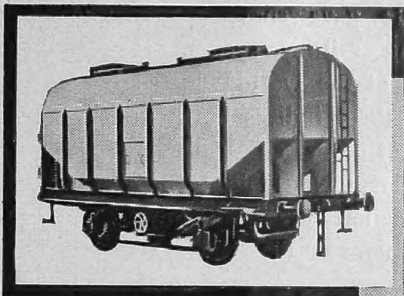
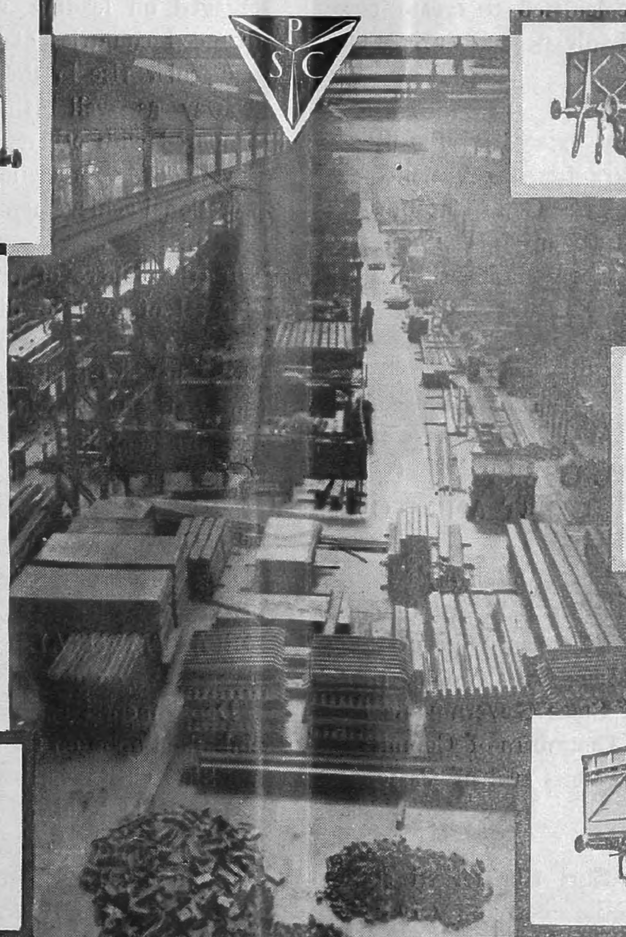
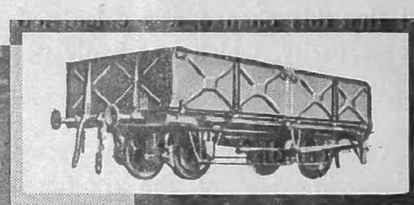


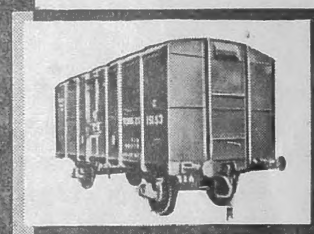
20-ton capacity Bulk Grain Van to the order of British Railways.



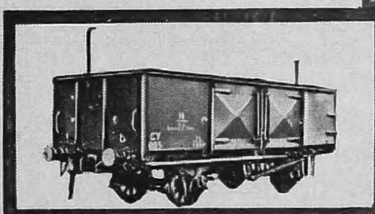


F.J.S. Low-sided Open type Wagon as used by Queensland Government Railways, Australia.

their service is world wide

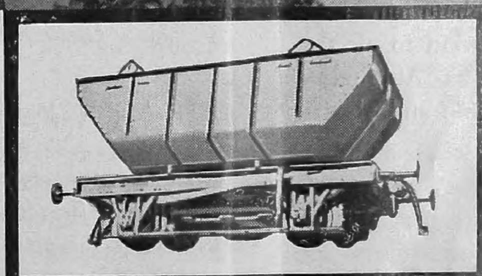


Broad gauge covered Wagon type C.R. as used by Indian Railways.



22-ton G.Y. type Wagon as used by Victoria Government Railways, Australia.

16-ton all steel Mineral Wagon, 50,000 of which have already been built in our Paisley works to the order of British Railways.



V. J. M. Hopper type Wagon with Drop Bottom Door as used by Queensland Government Railways, Australia.

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under execution on this Railway which, on completion, would greatly help in improving the position.

During discussion on the campaign launched by the Railways to "work the wagons harder", certain members referred to difficulties which might arise from the reduction in the free loading and unloading time which had been enforced. It was explained to the Council that this change was calculated to create new transport capacity, which was badly needed during the second Plan period.

The Council disfavoured any extension of railway concessions in view of the continued prevalance of overcrowding. The members of the Councilex pressed differing views on the proposal put up by the Railway Board for consideration whether any limits should be placed on the luggage carried by each passenger into the train.

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CENTRAL RAILWAY ZONAL USERS' MEET AND TOUR

The Tenth Meeting of the Central Railway's Zonal Users' Consultative Committee was held in Bombay on January 19th under the Chairmanship of Shri M. N. Chakravarti, General Manager. Among those present were representatives of State Governments and State Legislatures, Members of Chambers of Commerce, Trade and Agricultural Associations and of Passenger and Traffic Relief Associations.

Addressing the Committee, Shri Chakravarti stated that for the future, on those sections carrying very dense traffic where electrification was the solution, such projects for conversion of steam locomotion to electric traction would be on the 25,000 volts Alternating Current system which was both practicable and yielded the maximum economies.

OPERATIONAL EFFICIENCY UP

The greatest need of the hour, Shri Chakravarti stated, was to squeeze the maximum transport capacity out of our available resources which had lagged very substantially behind the growth of traffic. The Railways had striven hard to carry the extra traffic and the virtual clearance of all arrears of goods traffic was an index of the success of its endeavours. Efficiency statistics on the Central Railway of course, bore mute evidence of this progress, he stated. Wagon miles per wagon day and net ton miles per engine hour which were key indices of efficiency in wagon and engine usage had reached all time high in the last quarter of 1956, the former figure having consistently exceeded 60, a level never before achieved. In November 1956, the wagon miles per wagon day on the Central Railway reached 65.3. He gave some comparative results achieved on leading railway systems in several very advanced countries of the world which spotlighted the spectacular rise in these indices both over the Central Railway as well as over all Indian Railways when compared with others. Non-official Members recorded a vote of appreciation of these outstanding goods operational achievements on the Central Railway.

In the sphere of passenger operation, the problem of removal of overcrowding is being tackled with all the resources at our command, limited as these were, Shri Chakravarti stated. To this end, apart from the funds already provided for more engines, carriages, etc. programmes for large station buildings and for amenities other than the basic would be pruned so as to provide just what was necessary and the funds so released would be canalised for Railway's developmental plans and for mitigating overcrowding in the 3rd class.

DEPARTMENTAL CATERING DOING WELL

Departmental catering by the Railway's own staff was embarked upon on the Central Railway, less than a year ago Shri Chakravarti explained, but in this short period considerable headway had been made. Equipment was being modernised. Invaluable assistance had been lent by honorary lady social workers who had volunteered to pay surprise visits to the various catering units and to inspect them. Their reports had been most encouraging.

OUT-AGENCY FOR KHARGONE

Among the subjects discussed by the Committee was the action taken in cases of serious complaints. Wherever serious charges are levelled, a fact-finding enquiry is instituted to investigate the complaint and an opportunity given to complainants to attend such enquiries with witnesses to substantiate the allegations. The opening of an Out-Agency at Khargone to be served by Khandwa was found to be justified. The decision to have 50 per cent of the lavatories in I class compartments on the Indian style is being gradually implemented, members were advised. Members were

(Continued on page 5)

The Manufacture of Timken (Made in U.S.A.) Tapered Roller Bearings

THE Timken Roller Bearing Company of Canton, Ohio, U. S. A., has manufactured the only complete line of tapered roller bearings for over fifty-five years. (2) Suppose you were going to provide a bearing to ease the rotation of a wheel or shaft—a bearing which would virtually outlast the job it has to do. A bearing whose sturdiness would actually add to the life of the machine of which it is a part. A bearing that other people could take for granted. One thing you would want to do is design a bearing that would take all loads, regardless of the changing directions from which the loads might come. The second would be to produce it of materials so tough that it could endure these loads with practically no wear. And your third aim would be to construct it so accurately that it would turn out to be as ideal in fact as it was in theory.

LET US DESIGN THAT BEARING

Very little friction is present to impede the progress of a rolling object. Only a little gravitational force will start it and keep it going. An object that must rub instead of roll is confronted with a greatly increased impeding force of friction. What you want to do, then, is to get rid of as much of these rubbing motions as you can and replace them with rolling ones. If only one force at right angles to the axis of the bearing needed to be considered, such as the dead weight which the

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(Continued from page 4)

also furnished with Financial Statistics and Statements in regard to compensation claims, amenity works in progress and punctuality of passenger carrying trains.

NON-OFFICIAL MEMBERS TOUR

In keeping with the Indian Railways' policy of associating non-official public opinion with Railway working in an increasing measure, the non-official Members of the Committee at the conclusion of the meeting were taken round on a conducted tour of several railway installations both in Bombay and at upcountry centres accompanied by the Public Relations Officer. The itinerary included a visit to Bhusaval, Sanchi, Jhansi, Gwalior and Agra Cantt. stations. The members also inspected Nasik, Khandwa, Itarsi, Hoshangabad. Bhopal and Morena. While at Bombay the Members inspected Victoria Terminus and Wadi Bandar Goods Depot.

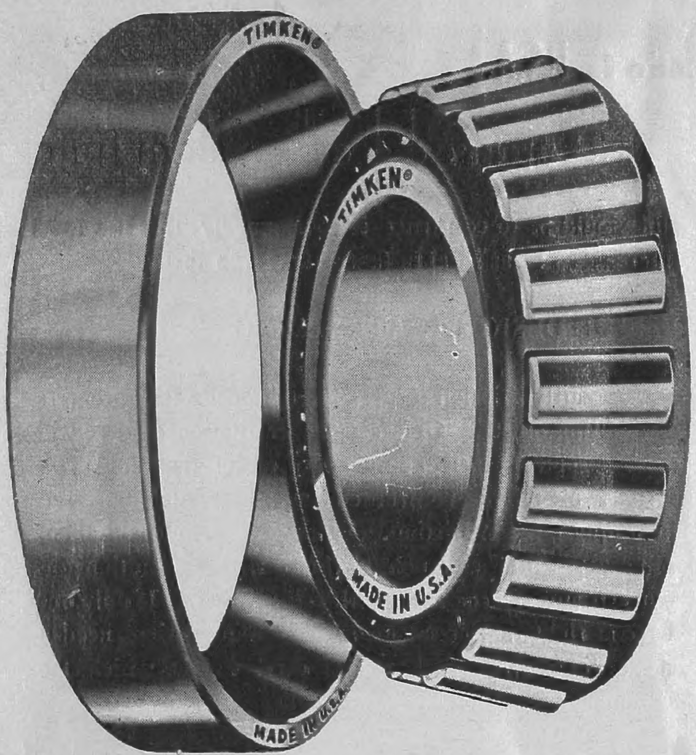
This conducted Tour was the second of its kind organised on the Central Railway and was intended to enable the Members, who are representatives of the various sections of Railway users, to see at first hand the inner working of the Railway. Based on their observations during the tour, the Members have made several useful suggestions for improvements in different types of services rendered by the Railway, particularly with reference to the various passenger amenity works and other facilities at stations. All these are being carefully processed.

MORE PASSENGER AMENITIES RECOMMENDED

Principal among their recommendations affecting passengers are the modernising of lavotaries by doing away with the basket system of disposal where it at present existed, and replacing it by water borne sanitation, provision of additional roof cover over platforms at the more important stations, more light on platforms, in waiting halls and booking office concourses where this was inadequate and more benches in the 3rd class waiting hall and on platforms where there were not enough at present and where the additional benches would not cause obstruction. The Members also recommended the lowering of the Sheet Time Tables and Fare lists and their resisting, where necessary, so as to be directly, under a light for better visibility at night. For third class waiting halls and booking offices, Hindi Time Tables and Fare lists were preferred. A buzzer, bell or loudspeaker arrangement has been suggested at some of the bigger stations where the 3rd class waiting hall is located far from the platforms so that passengers in the Waiting hall can be warned of the impending departure of trains 10 minutes in advance.

Members were very favourably impressed with the quality of food, the standard of cleanliness and the general upkeep of departmental catering units where the entire management including cooking and service of food was done by the Railway. Within the circuit of their tour departmental catering units at Victoria Terminus, Bhusaval and Jhansi came to be inspected and at these centres the Committee felt that the service was good.

At the conclusion of the week members long tour, remarked about the general improvement noticeable all round and complimented the local Divisional Officers on the progress achieved as was evident to them from what they saw.

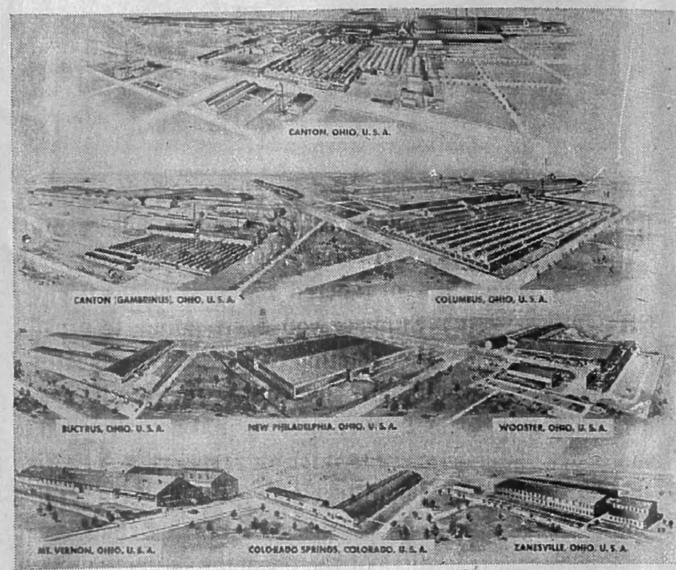


(1) This is the standard, single-row Timken (Made in U.S.A.) tapered roller bearing showing the cup, or outer race, on the left and the cone, rollers and cage on the right.

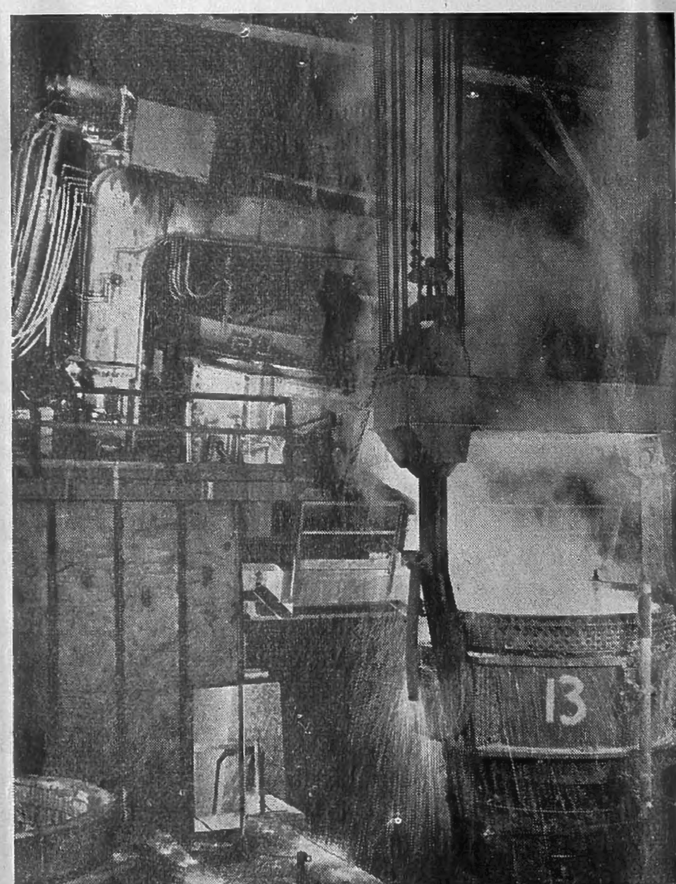
bearing supports, straight rollers would provide a complete answer. But the force acting on wheels and shafts rotating in everyday use is rarely, if ever, wholly axial or wholly radial. It is an ever-varying combination of dead weight and dynamic thrusts, bounces and lurches.

Timken (Made in U. S. A,) bearings are designed to take radial and thrust loads separately or in any combination. All Timken (Made in U. S. A.) bearings are designed with one geometric proposition in mind—lines drawn coincident with all rolling surfaces must meet at a point somewhere along its axis. This point is determined by the angles of the rollers. The Timken Company produces twenty-seven different types of tapered roller bearings in 5,850 sizes. There are bearings with one row, two rows and four rows of rollers. There are bearings which will carry loads up to two million pounds at 500 revolutions per minute and others which easily handle screaming speeas of many thousands of revolutions per minute. There are shallow-angle tapered roller bearings for applications in which radial loads are the main factor. And there are steep-angle tapered roller bearings for applications where thrust loads predominate over radial loads.

But basically, the component parts of the Timken (Made in U. S. A.) tapered roller bearing are the cup or

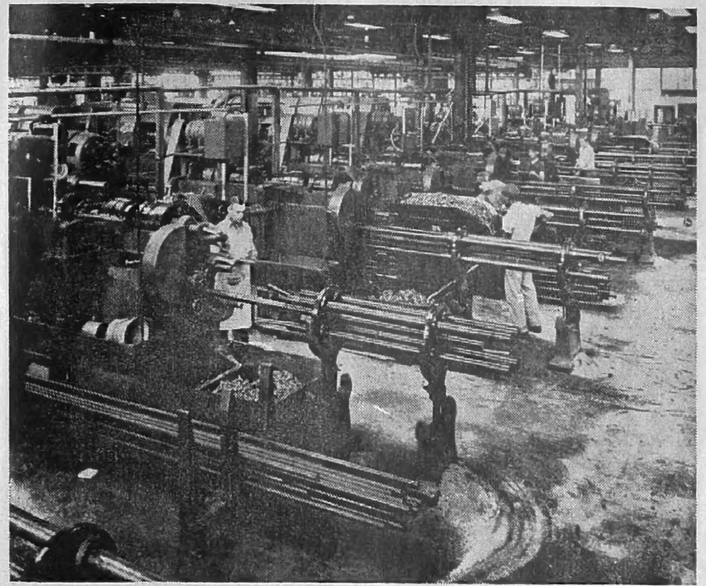


(2) These are the manufacturing units of The Timken Roller Bearing Co. in the United States.

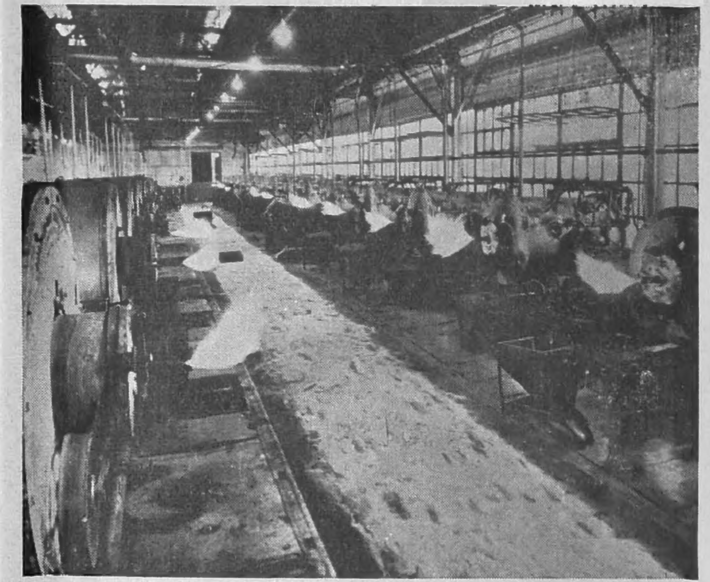


(3) An electric furnace melter (shown at the middle left) checks a heat of Timken steel as it pours into a ladle.

outer race; the cone or inner race; the tapered rollers themselves which roll between the cup and cone; and the cage, which bears on load, and does no work other than the light but important job of keeping the rollers spaced evenly around the peripheries of their raceways.

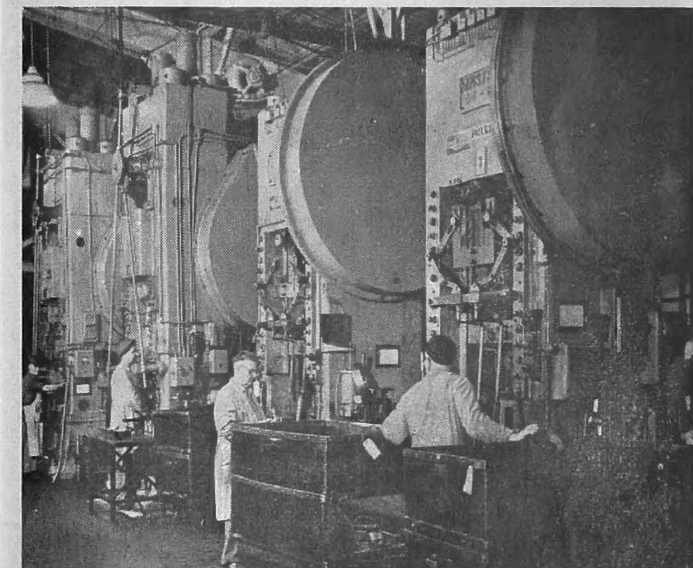


(4) A few of the four-spindle screw machines which perform the "green" machining operations on cups and cones.



(6) A general view of the Carburizing Department, showing the retort furnaces where Timken (Made in U.S.A.) bearing parts absorb carbon from the carbon-containing atmosphere.

(5) A general view of the Header Department where small—and intermediate—size rollers are formed.



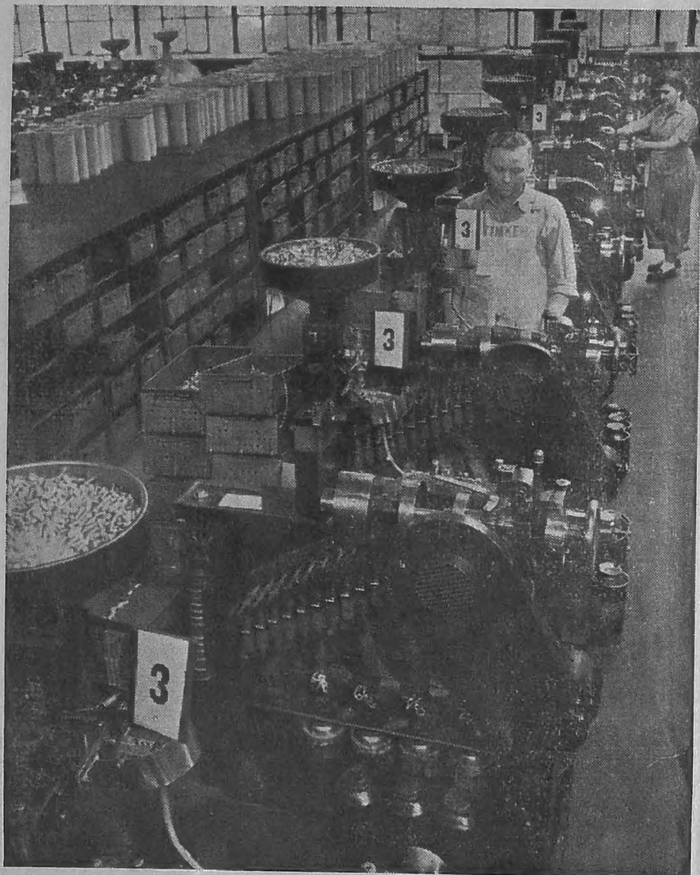
(7) These are a few of the cage presses which perform the blanking, sizing, perforating, winging and spreading operations.

Just as important as the design of the bearing and its components, when we are after bearings that other people can take for granted are the materials of which they are made.

THAT'S WHY THE TIMKEN COMPANY MAKES ITS OWN ELECTRIC FURNACE STEEL

The Timken Company is the only bearing company in the United States that makes its own steel and thus is able to control bearing quality from melt shop to finished product. (3)

The first operation in the "green" machining of Timken (Made in U. S. A.) bearing parts occurs in the single-and multiple-spindle high production screw



(8) These machines, designed by Timken Company engineers, split a thousandth of an inch into many parts and sort the rollers into groups in which the maximum variation can be as small as 125 millionths of an inch.

machines used to make the small—and intermediate-size cups and cones from Timken seamless steel tubing. After machining is completed, the parts are chamfered and the part number is stamped on each piece. (4)

Since the machining of bearing parts is followed by precision grinding methods, and since the Timken Company believes that quality is put into the product at the machine, quality control charts are used at these machines to make sure that the parts are held within specified dimensional tolerances. Special indicator-type gauges have been developed by Timken Company engineers so that quality control inspectors at the machines can constantly check the product and plot the resulting on the measurements on the charts. Machine operators interpret the chart information and make immediate machine adjustments, when necessary, thereby insuring a minimum loss of product.

Cups and cones larger than ten and one-half inches diameter are made, not from seamless tubing, but from forged steel rings. They call for larger, less automatic machines such as chucking lathes which rough out rings up to a foot and a half outside diameter. Cups, cones and rings as large as six feet across are rough turned and then finished on boring mills. These larger parts must be brought to size in two steps—first, they are rough cut; then, after being inspected and tempered, they are remounted on the boring mills for the finishing turn.

In the manufacture of rollers, the Timken Company is faced with the problem of the great variety of sizes. Small rollers up to 1—1/2″ diameter by 2—1/8″ long are produced on cold heading machines. (5) Rollers larger than header size, which may weigh as much as thirty-two pounds, must be machined on turret lathes from solid bar stock.

The next step in the manufacturing process is one of the most important with respect to bearing quality—heat treating. Timken (Made in U. S. A.) bearings must have hard-wearing surfaces, but also must be able to withstand shock loads. To meet these rigid requirements, the parts are first case-carburized and then hardened and tempered.

If your steel is right in the first place—and if you make it yourself, you know it is—then you can heat the machined parts to a controlled temperature . . . keep them in a carbon-containing atmosphere for a controlled length of time, and the steel parts will absorb carbon from the atmosphere. A rapid quench in oil, and the carburization is complete. (6)

Each carburized part is then reheated for hardening. To prevent distortion of the larger sizes of cups or cones, they are first centered in a hardening machine. Automatically a plug-like fixture engages the I. D. of the part to hold it in alignment while the sudden shock of an oil quench effects structure changes to produce a hard, wear-resistant surface and a softer but tough and shock-resistant core.

To complete the heat treating operations, the parts are tempered, usually in air, at about 350°F. in order to relieve stresses and brittleness created by oil-quenching hot steel. Any iron oxide scale found on the parts is removed by shot-blasting since this scale would be detrimental to grinding operations.

Now comes the wizardry of grinding, as dimensional accuracy and surface smoothness almost impossible to comprehent is imparted to the hardened surfaces.

The first operation on cones and cups is to grind the faces until they are parallel and an exact distance apart. Once again for small sizes, the work is rapid and automatic while larger parts call for larger, less automatic

machines which grind one face at a time. Surface after surface the cups and cones are brought to gleaming perfection. The inside diameter of a cup is the tapered, outer raceway of a bearing; therefore, the grinding of its surfaces is critical. Quality control techniques are employed to control the stand (the equivalent measurement of size), taper, runout, surface finish and visual characteristics. Machines vary in type and volume of production with changes in kind and size of parts, but the end objective is invariably the same—incredible accuracy.

Cone bores, which are not tapered, are ground on I. D. grinders very similar to those used for grinding the I. D. of cups.

Next the cone ribs are ground on Timken Company-designed grinders. The rib adds the mechanical feature of positive alignment. It is this surface which the large ends of the rollers contact as they move between the receways. From the rib grinders the cones are O. D. ground. And here again, quality control is rigidly maintained.

Meanwhile, rollers by the millions are being brought to the same smooth, dimensionally-exact perfection on other grinding machines—some slowly and painstakingly—still more at twinkling high production rates, but still painstakingly, for no matter the method or the size of the roller the taper must be exact and the surface must be right to make bearings that other people can take for granted.

Parts for the larger bearings go through the same basic grinding operations as the smaller ones. The huge grinders in the Special Finishing Department at Canton, Ohio, U. S. A., are capable of handling product up to six feet in diameter while holding dimensions to a tolerance which can be as small as two thousandth of an inch.

The bearing surfaces of the smaller parts are finish ground to around twenty-five micro-inches. If bearings could be made with perfectly smooth surfaces, their races and rollers would be absolutely smooth—that is, zero micro-inches. To make these surfaces as smooth as possible, the Timken Company hones them until their surface finishes measure within two to eight micro-inches. The Profilometer is used to measure surface finish of Timken (Made in U. S. A.) bearing parts.

Timken (Made in U. S. A.) bearing cages, which position each roller around the cone, are stamped from strip steel on presses ranging from 45 tons to 800 tons capacity. (7) The processes through which the cages go include blanking, sizing, perforating, winging, annealing, spreading and finally phosphating for protection against rust.

There is one more point to consider in our production story and once again it deals with the great variety of sizes of bearing parts. Finished and flawless, rollers of any one size will not vary in diameter more than a thousandth of an inch. But this is far too much so in a special machine with an uncanny ability to split a thousandth of an inch into many parts, the rollers are sorted into groups in which the variation in diameter can be as small as 125 millionths of an inch. (8) Rollers in any one group are then ready to share their work equally when a set of them are assembled in a bearing.

Now we arrive at the inspection, assembling and shipping operations. In the Finishing and Inspection Departments, cups, cones and rollers are visually inspected for surface defects and gauged on critical

(9) This is one of the automatic assembly machines which assembles the small-and intermediate-size bearings. The operator is shown filling a cage with rollers with her left hand while the right hand moves as assembled cone to the closing-in press. Her right arm has interrupted an electric eye beam which automatically indexes the press, moving completed assemblies out of the press and onto the conveyor at the bottom of the picture.

(10) A mill-size bearing is assembled, using large cage rings. The pins which hold the rollers are a few thousandths smaller than the holes through the rollers to insure proper running clearance.

dimensions. To pass inspection each cup must also be within the tolerances specified for stand and taper measured on specially-designed gauges. The Timken Company employs the physically handicapped when possible and several blind persons are now inspecting cups with electronic sound devices. The company has found that the quality of work done by the blind gaugers electronically is as high as that done visually.

Cones are visually inspected for steel and grinding defects the same as cups. They are also gauged for proper bore tolerances and sorted into size groups for matching with rollers on gauging machines.

Rollers are inspected on company-designed machines on which the rollers are automatically positioned in a circular spider. As the spider moves the rollers from left to right, a dial underneath the spider revolves counterclockwise thus rotating the rollers so the inspector can see the entire surface.

In the fastest assembly operation for small bearings, rollers are cleverly turned large end up as they enter the home stretch. The assembler positions a cage on a fixture and the machine automatically positions one roller in each cage pocket. The assembler then places a cone inside the cage of rollers and moves the assembly to the closing-in press which automatically closes-in the cage so that the assembly can't fall apart. (9)

The assemblies are finally automatically washed, greased and packed.

Of course, the mill-size bearings are inspected, assembled and packed under quite different conditions from the automotive-size bearings. Inspecting and gauging a roll neck bearing, for example, is a delicate proposition even though the completed bearing may weigh as much as four tons.

The rollers are first positioned around the cone and between two cage rings by means of cage pins. Pipe threads on the bottom end of the pin engage and lock in the tapped hole of the lower cage ring. The driven end of the pin protrudes above the upper cage ring and is welded into place. The diameter of the hole through the rollers is several thousandths of an inch larger than the cage pin to enable the roller to rotate freely. (10) The completed mill-size bearings are then given a thorough coating of oil or grease prior to packing and shipping. (11)

This then is how the Timken (Made in U. S. A.) tapered roller bearing is manufactured from scrap metal to finished product. It would not be complete, however, without a further word about the Timken Company's efforts to maintain its long-standing reputation for manufacturing the world's finest tapered roller bearing.

Precision tools and gauges are needed to manufacture a precision product like the Timken (Made in U. S. A.)

(11) A general view of the Shipping Department at the Canton, Ohio, U. S. A. bearing factory.

roller bearing. The Main Tool Room at Canton, Ohio, U. S. A., contains the lathes, milling machines, drill presses, shapers and precision grinding machines used in making these tools and gauges. In grinding master gauges, the toolmakers work to limits of fifty-millionths of an inch. The Precision Gauge Laboratory, the finest of its kind in the United States, inspects all work done in the tool room.

Some of the finest American-, Swiss-, German-, Swedish-, and English-made measuring instruments are located here. Angles may be checked to an accuracy of one second of an arc. If two straight lines, each one mile long, were made to form an angle of one second of an arc, they would be approximately 5/16 apart at the open end. This department is kept at a constant temperature of 68° and humidity is maintained at a percentage least conducive to rust.

Before production starts, research and development work is necessary. During the course of manufacture, constant testing is required to see that the raw material is up to standard, that the steel is being made properly, that it is of the proper hardness and structure, and that it is being machined to the best advantge. After the bearing is completed, it must be tested to see that it is best for the purpose, to determine its life in service and its resistance to special conditions such as overload and fatigue.

Highly trained, skilled chemists, metallurgists, engineers and research specialists are constantly working to maintain and improve the quality of Timken (Made in U. S. A.) tapered roller bearings ; seeking new ways to adapt materials and products to the ever-increasing demands of modern industry; developing new tests to determine just what causes certain results; how to attain desired properties consistently; how to reduce costs.

Timken Company employees are proud of the part they are playing in a highly specialized society. They know that Timken (Made in U. S. A.) tapered roller bearings met the requirements of the "machine age" and will meet the more rigid conditions on the "jet age."

HEAVY MACHINE-BUILDING PROJECT

According to a report, the first meeting of the Technical Committee appointed by the Government of India under the chairmanship of Sir Jahangir Gandhi to study the project reports submitted by the British and Russian experts on the proposal to establish a heavy machine-building industry in India will be held sometime this month. Besides the two reports, the Committee will also consider the report, submitted a few days ago by a team of Russian experts on manufacture of coal mining equipment in India. The Russian project, which is estimated to cost about Rs. 13 crores, provides for a foundry force exclusively for the plant for producing mining equipment. The British report of heavy machine-building plant includes on the other hand, a provision for production of coal mining equipment. The proposal which does not include foundry is expected to cost Rs. 3 crores.

* * *

STANDARD GUIDE

The Indian Standards Institution has published an Indian standard guide for inter-conversion of values from one system of units to another. This standard is intended to serve as a guide in converting numerical values of physical quantities from one system of units of measurement to another system of units. In particular, it should assist the designer and the draftsman in converting dimensions and tolerances on engineering drawings from inches to millimetres. It also deals with the conversion of monetary values, of interest to administrators, traders and industrialists. The preparation of this guide became particularly necessary because of the Centre's decision to adopt the metric system as the only system of weights and measures within a period of 10 years.

* * *

ALUMINIUM CASTINGS FOR CARS

The General Motors, New York is to build an Aluminium–Casting Foundry for motor car parts. The Foundry will be close to an aluminium reduction plant, planned by Reynolds Metals Company. This Foundry will be operated by the Chevrolet Division. In an agreement with Reynolds, the two plants will be close enough for molten aluminium to be carried from Reynolds electrolytic potlines for use in casting in the Motor Foundry. This would eliminate the casting of the metal into ingots and then remelting it. The Foundry is expected to be operated by June 1959.

Telecommunication Cables for British Railways

MANCHESTER-CREWE ELECTRIFICATION

THE British Transport Commission have announced the award of a £290,000 contract to British Insulated Callender's Cables Limited for the supply and installation of telecommunication cables on the Crewe-Manchester line as part of the Railway Modernisation Programme. This follows the recent award to the BICC Group of the supply and erection contract for electrification of this line and is a striking tribute to the techinal resources of the BICC Group. Both audio and carrier types of cable are included in the installation, together with distribution cabinets and trackside telephone cabinets.

Severe problems are set for the telephone cable designer by the presence of a 25kV alternating current traction system running in close proximity to telephone cables throughout their length. In conventional cables the voltages induced by high load or fault currents in the overhead traction system might be sufficiently high to cause damage to the insulation of the cable and connected apparatus, or to endanger the lives of people using the railway telephone system.

It is therefore necessary to provide heavy screening to keep the induced voltage on the cables within safe limits. BICC have developed for this purpose special cables having aluminium sheaths of sufficient thickness to give a low longitudinal resistance, and provided with a multiple steel tape armour of selected material to raise the external sheath impedance. The earthing of the cable sheaths is of the utmost importance in ensuring the effectiveness of the screening, and the BICC system of deep driven earthing rods is eminently suited to provide earthing points of low resistance at regular intervals.

It is of paramount importance that both the steel tapes and the aluminium sheath should be securely protected against corrosion, both from earth currents and local soil conditions because of their vital importance

for screening purposes. Very careful attention has therefore been paid to the protective serving which is applied over the steel tapes, this being the patent P. V. C. and rubber sandwich type which the Company introduced some time ago for use on power cables. In this connection the Company's wide experience of resolving corrosion problems has been of great value and it may be said that these cables are as well protected as any yet supplied to British Railways. A point of interest is that the security of the protective serving is tested by applying a voltage of 10 kV between the steel tapes and the coating of graphite with which the cable is finished: this means that a final test can be made after the cables have actually been laid so that the state of the serving need not be in doubt.

*** *** ***

CONSTRUCTION OF HEAVY MACHINERY WORKS IN INDIA

A group of Soviet specialists headed by Mr. N. I. Babich, Deputy Minister for Heavy Machine-Building of the USSR, at the invitation of the Indian Government have completed their work on preparation of a report on the construction of the first works for manufacture of heavy machinery and equipment in India.

On January 29, 1957, the report was submitted to Prime Minister Mr. Jawaharlal Nehru and to the Ministry of Heavy Industries, Government of India.

As Mr. Babich informed the TASS Correspondent, the construction of the aforementioned works will give a start to the creation in India of the most important branch of industry—heavy machine-building.

With the accomplishment of the works construction, India will be able to produce independently main heavy machinery and equipment for iron and steel and other industries. The works will manufacture machinery and equipment for crushing and grinding mills, coke and by-product plants, blast furnaces, open hearth furnaces, rolling mills and handling facilities for iron and steel industry as well as excavators, heavy drilling rigs for oil industry, winding engines for mines, forge and press machinery and other equipments.

The rated production capacity of the works will be 80,000 tons output of machinery and equipment per annum.

It will be able to produce annually metallurgical plants and equipment for one iron and steel works with the capacity of one million tons of liquid steel per annum.

The multi-purpose and powerful machinery of the works can be easily switched on for production of other types of heavy machinery and equipment according to the requirements of the economic development of the country.

In view of the fact that it is a complicated task to train high skilled designers, technologists and workers and to master the technology of manufacturing heavy machines, the Soviet specialists recommend to carry out construction of the works in two stages and the production capacity of the first part of the works is to be 45,000 tons of metallurgical and mining machinery and equipment per annum.

The report of the Soviet experts takes into account the decision of the Indian Government on construction of a specialized plant for production of castings and forgings. It should be borne in mind that the works for the manufacture of heavy machines will require casting and forging pieces of more than 100 tons weight each and of more than 100,000 tons total weight per annum.

To secure efficient work of the works of heavy machine building and to cut down expenditures for construction of both of the works, it is recommended to construct the plant for production of castings and forgings side by side with the works for manufacturing heavy machines.

According to calculations, these works will employ more than 10,000 workers and officers.

The report provides for the possibility of considerable expansion of the works with the progress of acquiring experience and mastering of already created capacities.

The complex of the works for manufacturing heavy machinery and equipment and of the plant for production of castings and forgings in India will be similar to the largest Soviet works such as "Uralmash" in the Urals and "Novokramatorsk" in the Donets Basin. It will be a very good school for training high skilled workers and leading personnel of heavy machine building industry in India.

Origins of Civil Engineering in Britain

INTRODUCTION

CIVIL engineering—the design and construction of such works as railways, roads, bridges, water-works of various kinds, docks and power stations—is of fundamental importance to every country's social and economic progress. Britain was first in the field in the modern development of civil engineering as a major industry and the first country to provide techniques, finance and equipment on a large scale to carry out civil engineering projects throughout the world. Thanks to its long experience, its persistent tradition of innovation and its high degree of flexibility the British civil engineering industry is now well-equipped to tackle every type of project whatever the locality. This paper provides a short sketch of some of the principal British contributions to civil engineering technology and of projects undertaken outside Britain by UK engineers and contractors.

Engineering has a long history in Britain, as in certain other countries. The Romans built many fine roads, harbours and bridges, though most of these later fell into decay and the relatively advanced techniques associated with them were lost. In the Middle Ages and sixteenth and seventeenth centuries numerous stone bridges were erected and some land drainage schemes brought into operation. Much of this early constructional work was, however, undertaken primarily to meet military and political need and the term 'engineer' denoted someone who designed and constructed engines of war, military highways and systems of fortifications.

Engineering in the modern sense as a major industry catering for civil needs really dates in Britain from the late eighteenth century when the UK economy was undergoing the momentous changes associated with the early Industrial Revolution. Radically improved techniques led to a greatly expanded output of iron, coal and chemicals, the invention of the steam engine revolutionized the outlook for power-driven machinery and a rich harvest of mechanical inventions helped to make Britain the leading world producer of cotton textiles and other consumer goods. At the same time, and partly as a consequence of the above changes, UK domestic and overseas trade showed a marked expansion in volume and variety, and the size of the population, after remaining fairly static for hundreds of years, began to rise rapidly.

Some of the changes completely transformed engineering techniques. Thus, the development of iron technology gave the British iron industry a strong lead over those of all other countries and provided an essential foundation for a large-scale engineering industry. Again, the invention of the steam engine by James Watt in 1765 not only led to a demand for engineers to design power-driven machinery and plant for factories, but also provided the essential motive power for the subsequent development of railways. Furthermore, the great increase in the number of mechanical inventions included some notable aids to engineering techniques, such as steam and pneumatic hammers, screening and washing plants, drilling machines, tower cranes and derricks.

The Industrial Revolution also touched off a vigorous demand for engineers who could effect improvements in transport. The unprecedented expansion of production and trade called for new and better roads, bridges, waterways and (later) railways, and for men who could apply to such constructional works the skill hitherto confined largely to the military engineers. This need was met by a number of engineers of remarkable ingenuity and enterprise. Some of these, e. g. James Brindley the canal builder and John Metcalf the blind road maker, had little technical training but great natural gifts, while others, such as John Smeaton and Thomas Telford, combined practical ability with considerable scientific attainment. These men were employed, not by the Government, but by individual employers or firms.

The task of training the large number of engineering craftsmen needed was undertaken by a number of big employers, such as Matthew Boulton, who were in the van of industrial progress. In London and other large towns machine tools were invented and manufactured which overcame some of the last obstacles to accurate workmanship. Thus, the difficulties of working with iron were overcome by the invention in 1794 of Henry Maudslay's slide rest, which holds and guides the cutting tool along the iron. In 1800, Maudslay introduced the screw-cutting lathe, which made possible a universal thread in screws. Joseph Bramah (1748—1814) was noted for the invention of patent locks, hydraulic presses and many other mechanical devices. Joseph Whitworth (1803—1887) inaugurated a system of standardized screw threads and machine parts. James

Nasmyth (1808—1890) invented a steam hammer (1839), a nut-shaping machine, hydraulic punching machines, and machines for cutting key ways in metal wheels of any diameter.

The technique of surveying had already made great strides through such developments as the introduction of the transit-theodolite, invented about 1550 by Leonard Digges, of a slide rule invented by Edmund Gunter (1581—1626) and of logarithms by John Napier (1550—1617) and Henry Briggs (1561—1630). During the Industrial Revolution many surveying instruments were perfected and used much more extensively than hitherto.

By the early nineteenth century Britain already possessed several thousand skilled and semi-skilled civil engineers. The importance of the new profession was signalized in 1818 by the establishment in London of the Institution of Civil Engineers, which was incorporated in 1828 by Royal Charter.

At first "civil engineering" denoted all engineering that was not military, but after the early nineteenth century it has found convenient to specialize. Civil engineering came to mean the kind of engineering associated with public works such as railways, docks, harbours, water storage and supply and drainage, while other branches of the profession came into existence to specialize on mechanical, electrical, mining, marine, chemical and aeronautical aspects of the subject.

Some of the outstanding early British achievements in civil engineering are described in the following section.

EARLY BRITISH ACHIEVEMENTS

Canals

During the late eighteenth century and early nineteenth century a system of canals and navigable waterways was constructed in Britain to enable the rapidly growing output of industry and its raw materials to be transported cheaply and smoothly. The constructional work often entailed considerable engineering feats, including the provision of tunnels, aqueducts, reservoirs, locks and hydraulic lifts.

Most of this arduous work was carried out by physical human labour. Mechanical aids, however, soon made their appearance. As far back as 1770 steam-powered pumps were already in operation and horse-driven mechanical excavators—forerunners of the 19th century steam excavators—came into use.

Prominent amongst the early canal engineers was James Brindley (1716—72)—who acquired his very thorough engineering skill by extensive practice—and John Smeaton (1724—92) who was also responsible for building the famous Eddystone Lighthouse off the Cornish coast and for designing steam engines for pit drainage purposes. The completion in 1761 of Brindley's first important work, the Bridgewater canal, was a notable event in early canal engineering. Constructed to enable coal to be conveyed from the Duke of Bridgewater's collieries at Worsley to the great commercial town of Manchester, the canal was carried over the river Irwell by an aqueduct and through the hillside by a tunnel a mile long. The Bridgewater canal was followed by the Manchester—Runcorn canal, the Trent and Mersey Canal and many others, built by Brindley and other great canal engineers, including Thomas Telford (1757—1834), John Rennie (1761—1821), Sir Edward Banks (1769—1835) and John Pinkerton (1761—1821). By 1830 there were 1,927 miles of canals and 1,312 miles of navigable waterways in England and Wales, 183 miles of improved waterways and canals in Scotland and 848 in Ireland. After 1830 canal building in the United Kingdom slowed down owing to the competition of railways, and by 1840 had almost ceased, but the Manchester Ship Canal, completed in 1893, was of great commercial importance. Its construction required the excavation of 53 million cubic yards of earth which was carried out with the aid of 97 steam navies, 173 steam locomotives, 6,300 railway trucks and over 200 miles of specially laid railway track. It was the first example of the use of large-scale mechanisation in earth-moving.

The experience gained by its engineers on internal canal construction enabled Britain to provide the skill and resources for the building of canals in several other countries. One of the earliest examples was the Middlesex Canal connecting the tidewater in the River Charles at Boston (USA) with the Merrimac River; it was constructed between 1794 and 1803 by Weston, a British engineer.

In Canada, British engineers built the Welland canal connecting Lake Ontario and Lake Erie, completed in 1829. One of the most important ship canals in Northern Europe, the Gotha Canal in Sweden linking the Baltic with the North Sea, was constructed in 1807 by Thomas Telford. The Amsterdam Ship Canal, which is 15 miles long and has one of the world's largest locks was constructed in 1862 by Sir John Hawkshaw.

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Roads

Many of the early developments in the scientific construction of roads took place in Britain. Amongst the pioneers was John Metcalfe (1717—1810) who, despite blindness, built many roads in Lancashire and Yorkshire using heather as a foundation where there was a soft subsoil, and digging ditches to drain away the water. Later developments are associated with the names of Thomas Telford (1757—1834) and John Loudon Macadam (1756—1836). Telford stressed the importance of strong foundations and studied the problems of gradient and road shape. Macadam devised a greatly improved method of road construction and maintenance, and evolved the 'Macadamized' surface—consisting of a thin layer of small angular fragments of stone, laid on a thoroughly drained subsoil.

By the methods ushered in by these pioneers a large number of roads were laid down in the late eighteenth century and early nineteenth century under the 'turnpike' system, i. e. a system of levying tolls on all users of particular roads, except pedestrians, in order to help to pay for the costs of construction and maintenance. By 1840 Britain, with over 22,000 miles of reasonably good roads, enjoyed a highway system which was then superior to that of any other country in Europe. After this period road construction and maintenance languished owing to the much greater transport opportunities offered during the golden era of railways.

After about 1860 there was, however, a partial revival in the importance of road transport owing to the new vogue for bicycling and the introduction of horsedrawn trams. The electrification of tramway systems and their extension to all major cities in Britain and many overseas countries was an important development of the late nineteenth century and one in which British civil engineers played a major part.

The new era of motor cars, which gathered strength after 1900, induced a vigorous demand for new and better roads. This led to intensive experimentation on the subject of road surfaces and the problem of preventing dust. Research with tar and bitumen led to the introduction of asphalt and coated macadam surfaces with a surface dressing to make roads cleaner and safer. Later, additional improvements were introduced with all-concrete roads.

Many of the techniques evolved by British civil engineers, from Macadam onwards, have been widely adopted in road construction and maintenance throughout the world. British engineers and contractors have, in fact, been responsible for the building of road networks in many countries. In East Africa, for example, they built 35,500 miles of roads, in West Africa 29,300 miles, in Malaya over 6,000 miles and in the West Indies 9,000 miles.

Railways

Britain was the birthplace of railways. It was the country in which railways were first developed as a public means of transport and the country which pioneered railway construction in every continent.

In a sense, the invention and construction of railways was the technical culmination of the Industrial Revolution and Britain's greatest gift to peaceful economic progress in the nineteenth century. Railways provided transportation with regular services at much higher speeds than anything previously available, and they could handle extremely large volumes of traffic, whether passenger or freight. In many countries the building of railways opened up vast areas which had previously been barren wildernesses. In all countries railways, perhaps more than any other single factor, brought about a tremendous expansion of trade and production and appreciably higher living standards.

Epoch-making events in the early history of railways were the invention of the steam engine by James Watt in 1765, of the steam carriage by Richard Trevithick in 1801 and of the railway locomotive by George Stephenson in 1814. The Surrey Iron Railway, opened in 1803 by William Jessop for horse-drawn freight trains, was the earliest-known railway open to public charter. The Stockton and Darlington Railway, opened in 1825, was the first public railway to use steam locomotives. The Liverpool and Manchester Railway, opened in 1830, was the first railway to use steam locomotives for regular passenger services as well as for freight. The opening of the London and Birmingham Railway in 1838, marked the debut of the world's first major trunk line.

Soon after the completion of the Liverpool and Manchester Railway British engineers and contractors were at work constructing networks of railways at home and abroad Railway constructional work involved difficult excavations of tunnels and cuttings and the erection of numerous bridges, viaducts and embankments. It called for technical and managerial ability of a high order to plan and estimate on a large scale and to take risks. And it enable Britain's civil engineering industry to attain full stature.

In Great Britain the mileage of lines of open to traffic rose from 1,857 miles in 1842 to 6,621 miles in 1850 and 8,954 miles in 1854. In one year, 1846, the number of persons employed on building railway in Great Britain was as high as 500,000 while another 50,000 were engaged on the operation of lines already open.

Abroad, British engineers and contractors extended their operations to Continental Europe and to every corner of the globe.

Joseph Locke (1805—1860) constructed some of the earliest lines in France (e. g. the Rouen-Paris Line), the Netherlands and Spain. George Stephenson (1781—1848) planned the railway network in Belgium, and his son, Robert Stephenson (1803—1859) constructed the railway between Cairo and Alexandria and advised on certain lines in Belgium, Scandinavia and Switzerland. Sir William Cubitt (1785—1861) was consulting engineer to the Sambre and Meuse Railway in Belgium and the Amiens and Boulogne Railway in France. Isambard Kingdom Brunel (1806—1859), the famous engineer to the UK Great Western Railway, was consulting engineer to various continental lines, including the Genoa-Turin railway in Italy. Sir Morton Peto (1809—1889) was responsible for the construction of several of the earliest lines in Scandinavia. Charles Vignoles (1793—1875), the inventor of the Vignoles rail, laid down railways in Germany, the Netherlands, Poland, Spain, Switzerland and Brazil. Sir John Hawkshaw (1811—1891) laid down railways in Germany and Russia and was consulting engineer to railways in India (Madras).

Most remarkable of all railway contractors was Thomas Brassey (1805—1870). With the help of his "industrial army", which sometimes amounted to 80,000 navvies in addition to technicians and administrators, Brassey and his partners carried out 170 different railway contracts involving the construction of nearly 8,000 miles of railways in five continents. These railways included several in continental Europe (Austria, Denmark, France, Hungary, Italy, the Netherlands, Norway, Poland, Spain and Switzerland) and in Argentina, Canada (the Grand Trunk Railway), India and Mauritius.

After about 1860, with most of the United Kingdom and European continental trunk lines already laid down, British engineers and contractors turned their attention increasingly to projects in more distant lands and tens of thousands of miles of line were built by new generations of contractors including Thomas Walker, Sir John Aird, Viscount Cowdray, Sir Ewen Jones, Sir John Norton Griffiths and many others.

In India and Pakistan British engineers and contractors laid down, from 1853 onwards, over 40,000 miles of railways. The training and bridging of some of the mightiest rivers in the world, e. g. the Ganges and the rivers of the Punjab, through lofty mountain fortresses were great engineering feats. In some areas the lines had to be taken up exceedingly severe gradients, and construction had to be carried out of long tunnels, difficult viaducts, deep cuttings and high embankments. Other formidable problems confronting the early engineers were extremes of temperature ranging from 10°F to 125°F in the shade, as well as earthquakes and floods. An early example of difficult railway construction was the Bombay-Thana railway, which was opened in 1853; this involved the construction of two lines over the formidable barrier of the Western Ghats to the Deccan. One of these lines rose about 1,200 feet in nine miles while the other rose 1900 feet in 14 miles.

The construction of the Burma railways included the building of the Ava Bridge over the River Irrawadi near Mandalay and the remarkable Gokleik viaduct.

For many of the overseas railways built by British engineers and contractors Britain supplied not only the skill, enterprise and labour, but also the necessary finance and the locomotives, rails and other equipment.

The completion of railway networks made radical differences to the internal economy of many countries.

In Argentina, for example, the rapid development of the meat industry was made possible because UK engineers and investors, encouraged by the Argentine Government, had opened up the interior with thousands of miles of railways. The railways enabled the national authorities to maintain law and order and facilitated the transport of livestock and crops, on a large scale, to the port of Buenos Aires for shipment overseas. The United Kingdom furnished the greater part of the technicians and equipment. The first railway—a six-mile line from Buenos Aires was laid down in 1857. By 1890 nearly 6,000 miles of railway were in use, by 1900 10,000 miles.

In Brazil British capital and technical ability played a predominant part in early railway construction. The first line was built by James Brunlees in 1867. British engineers were responsible for the first line in China (from Shanghai to Woosung) and were associated with the building of many of the important early lines, including those from Shanghai to Nanking, Soochow to Hangchow, Hangchow to Ningpo, Canton to Kowloon and Peking to Tientsin.

In East Africa British engineers built 3,000 miles of railway, in West Africa 2,750 miles and in Malaya 1,000 miles.

British engineers and contractors also built many of the lines in Australia, South Africa, New Zealand, Siam and many other countries.

Bridges

The Industrial Revolution led to great increase in the demand for bridges and at the same time made available new materials, e. g. iron and concrete, in place of wood, bricks and stone for their construction. Britain produced many bridge engineers of genius in this period, including Telford, George and Robert Stephenson, John Rennie and I. K. Brunel, who pioneered the use of new materials and initiated new methods of construction.

The world's first cast iron bridge was constructed over the River Severn, at Coalbrookdale, in 1777—79 by the English ironmasters, Abraham Darby (1750—91) and John Wilkinson (1728—1808); this bridge with its 100 foot span carried by a series of semi-circular ribs, is still in use. It was followed by the construction of several more cast iron bridges in Britain and overseas.

The first iron railway bridge, completed in 1824, was built by George Stephenson to carry the Stockton and Darlington Railway over the river Gaunless at West Auckland.

Many of the earliest suspension bridges were erected by Samuel Brown (1776—1852), who was responsible for several improvements in the design of such bridges. Thomas Telford's famous Menai Suspension Bridge in North Wales, built in 1826, was the world's largest span up to that time; the distance between the points of suspension was 579 feet, and there were 16 chains, each link made of five wrought iron bars. It is the prototype of all suspension bridges.

The first railway suspension bridge was built for the Stockton and Darlington Railway in 1830.

The first wrought—iron bridge is believed to have been a road bridge constructed over the Pollock and Govan Railway, in 1841. In 1846 Wm. Fairburn built a plate-girder bridge with a span of 60 feet to carry the Blackburn and Bolton Railway over the Leeds and Liverpool Canal.

The Britannia Railway Bridge over the Menai Straits, built 1846—50, was a successful early experiment in the use of wrought-iron tubes. The two main spans, each of 460 feet, were by far the longest railway spans at that time. The Conway Bridge—another tubular bridge, with a span of 480 feet, was being built at the same time. Both bridges are still in use.

The success of these two erections led to the building of many other tubular bridges at home and overseas, including the Victoria Bridge over the St. Lawrence River at Montreal. With a length of 6,600 feet (9,084 feet including the abutments and embankments) this bridge, which was designed by Robert Stephenson and opened in 1860, was the longest tubular bridge ever built.

In 1850 construction was completed of the first Warren Truss Bridge, which was built to carry the Great Northern Railway over a branch of the River Trent near Newark, Notts. Two notable truss bridges designed and constructed by I. K. Brunel (1806—1859) were the Chepstow railway bridge (built 1852) and the Saltash railway bridge over the river Tamar in Cornwall (1859)—which has two spans of 455 feet each, with lenticular trusses.

Steel and concrete were employed extensively in the construction of bridges by UK engineers in the second half of the nineteenth century. An impressive example is the Firth of Forth Bridge, which was opened in 1890 and was for many years the heaviest steel constructional work in the world. Designed by Sir John Fowler and Sir Benjamin Baker, the bridge has two spans of 1,710 feet and the bridge proper, exclusive of approaches, is over a mile long. The cantilever arms were constructed with tubular compression members, some of them 12 feet in diameter.

British engineers have also erected many important bridges overseas. Nearly all the railway bridges in India and Pakistan for example, were built by British engineers and contractors. Several were built of wrought iron or steel, with many spans, supported on brick walls which were sunk in sand. In Canada, at first timber trestle bridges and afterwards steel and concrete bridges were put up to carry the railways. In Australia and New Zealand most of the early bridges for railways and highways were constructed chiefly of timber and several of them are still in use. The great Sydney Harbour bridge designed by Sir Ralph Freeman was completed in 1932 by the firm of Dorman Long. It embodies a steel arch 1,650 feet long and carries four railway tracks, a 57 foot roadway and two footpaths; its total length is 3,770 feet. In South America some hundreds of railway bridges have been

built by British firms. Amongst outstanding bridges erected by British engineers in Europe have been the suspension bridge over the river Dnieper built by Charles Vignoles at Kieff, the Vila Franca bridge over the Tagus near Lisbon and the Storstrom bridge in Denmark. The Storstrom bridge, the longest in Europe, provides a through route for railway and roadway over two miles of water between Copenhagen and the continent of Europe, that is, between Zealand and Funen.

The many notable bridges built by British engineers in Central Africa include the Victoria Falls bridge completed in 1905, with a 500 feet span over the Zambesi River 400 feet below, the Birchenough Bridge over the Sabi River, the Otto Beit Bridge over the Zambesi and the Lower Zambesi Bridge in Portuguese East Africa (the third longest bridge in the world).

Tunnels and Subways

British engineers gained considerable experience in the boring of tunnels when the canal system was inaugurated. The early English canals were taken through some 45 tunnels, with a total length of more than 40 miles. One of these, the Marsden tunnel on the Huddersfield canal, is over 3 miles long and is believed to be the longest canal tunnel in the world.

The longest of these early tunnels still in use takes the Grand Union Canal 1¾ miles through Blisworth Hill in Northamptonshire.

The coming of railway greatly increased the demand for tunnel construction. Notable early railway tunnels were: the tunnel on the Liverpool and Manchester Railway completed in 1831 (the world's first railway tunnel); the Kilsby tunnel, nearly 1½ miles long, built by Robert Stephenson on the London and Birmingham Railway; and the two Woodhead tunnels, each three miles long, constructed on the Manchester, Sheffield and Birmingham Railway.

The oldest under-water tunnel in the world is M. I. Brunel's Thames tunnel in London, completed in 1843 after attempts extending over 40 years. It is 1,200 feet long, was lined with brick laid up in Portland cement and is still in use; it was used at first for vehicles and pedestrians and later for electric trains.

The first underwater tunnel of importance attempted through solid rock was the Severn tunnel, 4⅓ miles long, carrying the main railway line from England into Wales. It was constructed by Sir John Hawkshaw and opened in 1886.

A notable example of the application of British experience in overseas countries was the construction of the first railway tunnel through the difficult mud of the Hudson River, New York. This work was undertaken by a company headed by Weltman Pearson (later Viscount Cowdray) in 1890—91. While the work was being carried out one of the firm's directors invented a medical air lock still used to alleviate certain illnesses arising from working under high pressures.

Tunnel construction techniques were greatly improved by Thomas Cochran, who in 1830 invented a method of using compressed air to sink shafts and tunnels under water, and by Barlow (1809—85) and Greathead (1844—96) who invented the 'Greathead Shield'. In combination with compressed air this apparatus made underwater tunnelling not only possible but relatively safe. It was first employed in 1869 on the Tower Subway (London).

Credit for the first underground railway system goes to the Metropolitan District Railway in London. Work was started in 1860 and a portion was completed in 1863 and another part in 1868. This system was, however, built by digging deep trenches and covering over. Tube railway tunnels, driven at great depth through the London clay, using the Greathead Shield in conjunction with compressed air, were begun in 1886, and the main system was completed by 1907. London now has the largest and best equipped underground system in the world with 250 double or twin track miles (ninety of them below the surface) serving 277 stations.

The first cable-operated underground railway in the world was constructed in Glasgow between 1891—97; in 1935 it was electrified.

Docks, Harbours and Lighthouses

The building of docks, harbours and lighthouses has for long held an important place in British civil engineering owing to Britain's maritime traditions. In the eighteenth century the demand for these works received a tremendous impetus from the rapid expansion of UK overseas trade and of the size and number of trading vessels.

The world's first wet dock, the Howland Dock, was constructed at Rotherhithe, in the Thames, as far back as 1690—1700. It was 1,070 feet long, 500 feet wide and 17 feet deep. Soon after 1700 several docks were constructed at Liverpool, Hull and Bristol. Between 1789 and 1828 London was equipped with an extensive dock system enabling it to cope with nearly two-thirds

of UK overseas trade, which already constituted a high proportion of total world seaborne trade. The London dock area was nearly doubled by additional construction between 1850 and 1886, and by the end of the century London possessed 26 miles of docks, extending from Tower Bridge to Tilbury. An important addition in the twentieth century was the George V Dock, completed in 1921. Commensurable dock systems were built at other British ports. At Liverpool, for example, the dock area was extended from 27 acres in 1816 to over 500 acres in 1900. Harbours and docks were also built on a large scale at Naval centres such as Portsmouth and Chatham and at coaling centres like the South Wales ports.

Power-driven appliances—in the form of steam pumps and piling frames—were used in dock construction as far back as 1800. Later on, British engineers initiated many other innovations in techniques, including the use of screw piles (1838), and pile-driving by steam hammers (1846) and by jets (1850).

The boom in shipbuilding, the change from sail to steam and from wood to iron and to steel, led to much new civil engineering work and gave scope for ingenuity and enterprise in the building of berths, shipways, graving docks, wharves, piers, jetties and breakwaters.

Beginning with Thomas Telford (1757—1834), Britain established a heritage of great dock engineers. They contributed to dock and harbour building in many overseas countries. Amongst the nineteenth century examples were the large Callao dock in Peru, built in 1870 by Thomas Brassey, and the docks at Singapore, Colombo and Tampico (Mexico).

The technique of modern lighthouse construction owes much to the pioneer work of John Smeaton (1724—1792), who rebuilt the famous Eddystone Lighthouse, and of John Rennie (1761—1821), who, in conjunction with Robert Stephenson, built the Lighthouse on Bell (Inchcape) Rock opposite the mouth of the Tay.

Land Drainage and Irrigation

After the Roman occupation, land drainage received little attention in Britain until 1630 when a vast scheme, initiated by Sir Cornelius Vermuyden (1595—1683) for the Earl of Bedford, was carried out to drain the Fens and thus convert marsh, bog, and waste land into highly fertile arable land and pasture. Hundreds of channels were cut, sluices were built, to hold back the tides, rivers were changed in course and several highways and bridges erected. In the early nineteenth century many new systems were introduced by famous canal engineers and contractors, including John Rennie, Sir Edward Banks, William Jolliffe and Sir Morton Peto.

More recently, a great deal of civil engineering work has been carried out on Britain's main rivers and this has considerably increased agricultural yields. The work has required the construction of weirs, sluices, embankments, extensive dredging work and the widening and straightening of river courses. An outstanding example is the Great Ouse flood relief scheme, at present nearing completion.

Overseas, British engineers and contractors have carried out some projects of outstanding importance. In Egypt they introduced modern methods of irrigation into the Nile valley, and in 1898—1902 built the Aswan dam, $1\frac{1}{4}$ miles long and 130 feet high, with 180 large sluice gates. Together with the Asyut barrage (completed in 1902) and the Esna barrage (completed in 1912) these works, which were undertaken by Sir Murdoch Macdonald and other British engineers of outstanding ability, made possible the irrigation of 400,000 acres in Middle Egypt, in addition to a large tract in upper Egypt. Supplementing these works were several other major schemes and the Aswan dam has been twice heightened and strengthened, thus increasing its storage capacity five-fold In India and Pakistan the immence irrigation projects carried out by British engineers resulted in the construction of 80,000 miles, of canals, providing for an annual irrigated area of over 70 million acres.

Gasworks

Gas lighting was invented by a Scotsman, William Murdock. In 1802 he staged a public exhibition to show the value of gas lighting in factories and the following year a gas lighting system was in operation in Soho, London. By 1819 London possessed over 51,000 street lamps, supplied by 288 miles of gas mains, and similar developments were occurring in other parts of the United Kingdom. The expansion of the gas supply industry, particularly after 1850, called for some civil engineering constructional work of a varied type including gasholders, pipelines, roads, railways and jetties. The Beckton works in Essex, built by Sir John Aird had a capacity of 10 million cubic feet a day in 1870 and was then the largest in the world; since that time its capacity has been expanded sixteen fold.

As a result of continuous research gas manufacture has become much more efficient and this has involved

the use of complex installations, including conveyors, bunkers, crushers, carbonisation plant, purification and storage plant and cooling and grading plant. Extensive and complicated excavation work is required as well as specialized structural work. Gas production in Great Britain rose from 349,000 million cubic feet in 1938 to 521,000 million cubic feet in 1954.

Constructional Materials

The development of such vital constructional materials as iron, steel and cement for use in the civil engineering industry owes much to the work of British pioneers.

Although iron has been known and used in many countries for nearly 10,000 years it was not until the eighteenth century that it became possible to produce it relatively inexpensively and in large quantities. This great advance was mainly attributable to the work of Abraham Darby (1711—63), who discovered a method of smelting iron with coke instead of charcoal, John Wilkinson (1728—1808)—the "iron-mad master"—who, in 1755, greatly developed the use of coke blast furnaces and Henry Cort (1740—1800) who patented grooved rolls in 1783 and in 1784 produced wrought-iron in coal-fired furnaces by the puddling process.

The production of steel made great strides forward through the work of such pioneers as Huntsman, who succeeding in melting steel in a crucible and then casting it. In the nineteenth century steel production was revolutionized by the work of Henry Bessemer (1813—98), who in 1856 announced a new and inexpensive process—the Bessemer converter—of converting molten iron into steel, and Gilchrist Thomas (1850—85), who discovered a method for using phosphoric ores in the Bessemer process and thus made possible its widespread adoption on the continent of Europe. A further notable advance was the invention by Sir William Siemens (1823—83, naturalised as a British subject in 1859) of the open-hearth process.

Britain was responsible for most of the important discoveries in the development of the cement industry. The first major advance was in 1756 when John Smeaton (1724—1792) carried out research to find a mortar which would set under water and which he needed for building the Eddystone lighthouse. Smeaton's observations led him to the discovery that hydraulic lime made from limestone which contained clay set in water better than a pure lime, and he used for the erection of the lighthouse a cement produced from a blue lias lime together with pozzolana, from Italy.

A further discovery came in 1796 when James Parker introduced 'Roman' cement made from certain clay pebbles which were burned in a kiln and afterwards finely ground.

Portland cement was patented in 1824 by Joseph Aspdin (1779—1855) after experiments lasting since 1811. Other pioneers in the manufacture of hydraulic cements in the early nineteenth century included Charles Pasley (1780—1861), who undertook some of the earliest-known mechanical tests of the properties of cement mortar and concrete, and James Frost, who patented what he called 'British' cement in 1822.

One of the earliest edifices made with Parker's cement was the Chirk Aqueduct which carries the Ellesmere canal across the river from Shropshire to Denbighshire. Constructed by Thomas Telford, this aqueduct is 710 feet long and 22 feet wide and has 10 arches of 40 feet span; it was completed in 1801. Aspdin's cement was used by I. K. Brunel in 1828 in constructional work on the Thames Tunnel. The first work of great magnitude on which Portland cement was used was the London Main Drainage Scheme, designed in 1859 by John Grant.

Early pioneers in methods of wood preservation included William Burnett (1779—1861), who developed the use of zinc chloride, and John Kyan (1774—1850), who patented the 'Kyanising' (corrosive sublimate) process in 1832. Experiments in the use of creosote for wood preservation were carried out in Britain as early as 1756 and developed by John Bethel in 1838.

RECENT AND CURRENT CONTRIBUTIONS

This section touches upon some British achievements in civil engineering in recent years, at home and abroad.

Technology and Materials

Perhaps the most outstanding development in civil engineering technology in recent years has been the greatly increased mechanisation of constructional work, thus enabling the available labour forces to be used to much greater advantage and large-scale contracts to be executed in much shorter time than hitherto. Credit for much of this development goes to the United States, but Britain has also made some important contributions, especially as regards conveyor belt and coal handling machinery.

Particularly important advances have been made in the techniques of earth excavating and site clearance

which frequently constituted the largest single item in costs. In this sphere there have been two significant inventions—of commercially successful compression ignition oil engines and of track-laying machines to enable work to be carried out on soft and water-logged ground. Patents for early oil engines were taken out in Britain in 1890 by H. A. Stuart and R. C. Binney, three years before those taken out by Dr. Diesel in 1893. The first successful track-laying tractor was introduced by D. Roberts in England in 1905; it could pull heavy loads over boggy ground or loose sand or up a gradient of 1 in 2 on slippery clay. Since those pioneer achievements there have been considerable developments, and engineers in Britain and other countries have evolved some powerful devices with versatile capabilities. Examples of modern excavating plant produced in Britain include a range of diesel-electric grab dredgers and walking drag lines.

UK welding techniques for civil engineering are being improved by the use of such devices as electronically controlled oxygen cutting machines, by electric arc welding and automatic stud welding.

Similarly, UK road-making techniques have been revolutionized by a wide range of new machines for excavating, laying down foundations, concreting and surfacing. Other examples are power graders and automatically controlled concrete mixing plants, with mobile spreading and finishing machines. With this new equipment it is now possible for a small team of men to lay down about 350 yards of concrete road 24 feet wide in one day. Road making has also been assisted by the application of research findings on soil mechanics, and on methods of stabilizing soil foundations.

Mechanisation has also been advanced by the close links between the civil engineering industry and the mechanical and electrical engineering industries. This has been particularly fruitful in the production of new types of powered hand tools. One example is the development, mainly for rock drilling, of a means of absorbing dust at the very source of its generation at the tool tip.

Another recent development in civil engineering technology has been the extensive employment of unit construction processes in projects where economy of time, materials and labour are of first importance. In bridge building, one example is the Callender Hamilton unit construction material developed before the second world war and used extensively for civil and military purposes, in the United Kingdom and the Middle East. Another example is the Bailey Bridge introduced by Sir Donald Bailey during the second world war. This bridge, which is of steel, can be assembled by hand to meet varying conditions of span and load. It is already proving of great value in under-developed countries as it can, for instance, be rapidly erected across deep ravines or fast-flowing rivers. Another unit construction bridge is that made by the Butterley Co. It consists of five standard units which are built into a series of isosceles triangles. This bridge has been used extensively in South America and Africa for development work.

Concrete manufacture in Britain in recent years has been improved by the wide-spread use of methods of mix design based on new scientific data and by the application of quality control. In the use of concrete, notable developments include large concrete roofs, in the form of domes or vaults, so designed that they can be safely supported on thin columns or on thin walls. Pre-stressed concrete, the output of which has steadily increased, is employed for several notable large structures, e. g. the new hangars at London Airport, as well as for small erections.

British civil engineers have also made extensive use of new metallic alloys and of synthetic materials, e. g. of polythene for carrying corrosive industrial wastes.

Research into various aspects of civil engineering is carried out by the Ministry of Works, the Department of Scientific and Industrial Research, the Admiralty, various Universities and by individual firms and trade associations. One example is the research work on concrete manufacture which has been carried out over the past twenty years by the Building Research Station and the Road Research Laboratory in conjunction with UK universities and the Cement and Concrete Association. Another is the research carried out at the National Physical Laboratory into the effect of wind-pressure on bridges. This work has been carried out since 1946, with the aid of wind-tunnels for the scale models. The research led to the discovery of two types of aerodynamic instability—an up and down motion of the whole platform and oscillations of a twisting character. Methods were evolved to modify or eliminate this instability.

At the Imperial College of Science and Technology important research has been carried out to discover the manner in which waves exert shock pressure on walls—a matter of considerable importance to civil engineers, especially for maritime structures.

Recent Work in the United Kingdom

Within the United Kingdom British civil engineers and contractors have, in recent years, undertaken an immense volume of constructional work, including projects in entirely new fields, such as atomic power stations.

Constructional Work in Second World War. The constructional work undertaken during the second world war can only be referred to very briefly in this paper. It included the construction of 440 airfields with runways, taxiways and hardstandings equivalent to 3,000 miles of double carriageway roads, and a large number of military docks, harbours, roads, bridges, railways and bombproof buildings and repairs to essential services, which were severely damaged by enemy action. A great deal of research work on the properties of materials and structures under various adverse conditions was undertaken. The many striking innovations included 'Mulberry' and 'Pluto'. 'Mulberry' was the name given to an artificial prefabricated harbour which was towed across the Channel in sections and used in the early stages of the Anglo-American invasion of Normandy in 1944. 'Pluto' (popularly translated as: 'pipe lined under the ocean') referred to a system of cross Channel pipe lines which were laid down to maintain supplies of petrol to the Allied forces during the invasion.

Transport. Since the war, civil engineers have been occupied with much reconstruction and modernization work. On the British Railways, for instance, which today comprise some 19,060 route miles of permanent way, 63,100 bridges, and 1,050 tunnels, track is being relaid at a rate of over 1,800 miles a year, and an extensive programme of bridge repairs and renewals has been undertaken. Railway electrification schemes planned before the 1939—45 War have also been completed, including the Manchester to Sheffield route. This work involved a notable engineering feat in the construction of a double line Woodhead Tunnel through the Pennine Range to replace the existing one. This new tunnel which is over three miles in length, is the third longest in the country, and it took 5½ years to build owing to the treacherous nature of the rock through which it was driven.

In January, 1955, the British Transport Commission published an outline of a 15 year modernization and re-equipment plan, costing about £1,200 million. This plan includes the introduction of diesel traction on a large scale, the electrification of some 1,210 route miles of trunk and suburban lines on the high voltage A. C. system at a standard frequency, as well as many more reconstruction projects and bridge renewals.

Between the wars there was a considerable amount of constructional work on road improvement and on the building of arterial roads throughout the United Kingdom. In and around London, for instance, some 260 miles of arterial roads were completed, in addition to several by-passes and new roads in other industrial centres. A notable road tunnel built in this period was the Mersey tunnel, opened by King George V in 1934. The underwater section was driven over 5,000 feet through red sandstone; it was lined by 44 feet diameter cast iron rings across which the roadway was supported.

The United Kindom's public road system amounts to about 200,000 miles and is one of the densest in the world. Economic difficulties since the war restricted expenditure on major improvements and new construction, but in November 1954 the Government announced an expanded programme of road construction, and improvement designed to increase safety on the roads and to relieve congestion, and in February 1955 announced its intention to spend £147 million on these projects between 1955 and 1959. Of the more notable post-war contracts mention may be made of the Neath road in Glamorganshire. Three-quarters of a mile long, with dual carriageways each 22 feet wide, it was completed in 1955, and reduced the road distance between the two major towns of Cardiff and Swansea by six miles.

Modernization and extension work on British docks and railways has continued. It has taken account of such new developments as the rapid expansion of the UK oil refining industry the increasing size of oil tankers, the siting of power stations on the coast the growth of car transport by sea and the need for more dry dock facilities for repair and maintenance of shipping.

At the port of Liverpool the value of the reconstruction and development work now in hand is of the order of £25 million. On the Manchester Ship Canal an important new oil dock has been completed at Eastham and several improvement projects are being carried out. On Tyneside a number of new dry docks have been built, some of them by novel constructional techniques, including the use of 10-ton precast ribs. The extensions at Southampton, which was developed before the 1939—45 War into Britain's principal passenger port, capable of handling vessels of over 80,000 tons, include new cargo and passenger terminals. At Dover twin loading

berths for the new car ferry terminal were opened in 1953. At Preston a new ferry terminal has been built to connect with both Northern Ireland and the Irish Republic, and able to carry very heavy loads.

These are merely a few examples of the considerable volume of civil engineering work on docks and harbours which is being carried out throughout the United Kingdom.

Air transport has added a new facet to civil engineering. Before 1939 most civil airports had grass landing strips and the principal constructional problems were the provision of adequate drainage and levelling the ground. The steady increase in size and weight of aircraft was, however, rendering such grass strips obsolete, and in 1937 Royal Air Force airfields began to use concrete runways. During the war some hundreds of service airfields were constructed with concrete runways In more recent years concrete airstrips have been constructed of greater depth to support airliners of up to 140 tons, and with heat resistant surfaces to cope with jet aircraft.

Amongst the great civil airports built in recent years pride of place must go to London Airport. Its runways, tracks and parking places cover about 1,000 acres. Constructional work included the excavation of 16 million cubic yards of earth and the laying of 1¾ million cubic yards of concrete, 91 miles of drainage pipes and 145 miles of ducts for airfield lighting. The airport was first brought into use in 1946 and the first stage of permanent terminal buildings in 1955. The main access tunnel for road traffic, under the London-Bath Road, is over 2,000 feet long, 86 feet wide and 22 feet high. It provides footpaths, cycle tracks and twin carriage ways, each twenty feet wide.

Water Supply. Britain's water supply system, steadily improved over the past 150 years, now brings purified water on tap to 97 per cent of the population, a higher proportion than in any other country. Since the war, many further improvements have been introduced and entirely new local systems have been constructed for satellite towns. The civil engineering works carried out have often been on a large scale, requiring the laying down of thousands of miles of mains and the provision of long pipe lines, dams, reservoirs, aqueducts, pumping stations and filtration beds. For example, at Hemel Hempstead—a satellite town designed to contain 60,000 people—the new supply system called for the construction of a reservoir to hold 3 million gallons, a 200,000 gallon water tower for high-level supply, and a pumping and booster station in addition to 11 miles of track and 72 miles of distribution mains. The new water supply system for the city of Manchester (population over 700,000), opened in 1955, includes a system of steel syphons which convey 25 million gallons of water a day to Manchester from Lake Haweswater, 82 miles away.

Drainage and Sewerage. Progressive improvements in public drainage and sewerage systems have been a major factor in raising the general expectation of life in Britain from about 40 years at the beginning of the nineteenth century to the present figure of about 70 years. Today, about 90 per cent of the UK population are served by piped drainage and sewerage system and over 60 per cent by sewage treatment plants.

Civil engineering work in this field includes the construction of sewers for domestic and industrial waste, drains for surface water, outfall installations and sewage treatment plants—often of a very complex character. Often the tunnelling work has to be carried out in very difficult water-logged ground.

Notable amongst recent constructions is the treatment plant at Mogden in West Middlesex. Occupying an area of 50 acres, this plant has a total tank capacity of 100 million gallons and is capable of handling a normal daily flow of 75 million gallons with a maximum of eight times that quantity in wet weather. It serves a population of 1,400,000.

Oil Refineries. The construction of a petroleum refinery makes exacting demands on both the civil engineer and the chemical engineer. In addition to the highly complex chemical installations it is frequently necessary to provide roads, railways, power stations, oil wharves, cooling and drainage systems on a very large scale. Since the war, a major refinery industry has been built up in the United Kingdom with the result that actual production of refined products rose from about 5 million tons in 1948 to about 27 million tons in 1955.

Electricity Supply. The expansion of the United Kingdom's electricity supply system has made considerable demands on the civil engineering industry., Following the opening of the first public power station at Godalming in Surrey in 1881, a variety of independent power stations were built throughout the country. In the inter-war period, a notable achievement was the development of the 'Grid' system which linked together the most efficient power stations regionally. This entailed the use of 3,600 miles of lines and cables and the construction of tens of thousands of steel supporting towers (pylons). After 1945 a vast new development

programme has been inaugurated. Over fifty new power stations (coal or oil-fired) have been completed, over 1,400 route miles of cables and pylons added to the Grid System and work has begun on a 1,200 mile super grid to transport power economically in bulk from coalfields to points supplying the existing grid. This work has necessitated the construction of foundations (chiefly on piles), cooling water systems, tunnelling in compressed air and marshalling yards and jetties to handle coal and oil supplies.

Over 95 per cent of Britain's electricity is at present obtained from coalfired steam generating stations. This is attributable to the fact that Britain has for long enjoyed plentiful supplies of coal, together with good railway and water transport for coal, whereas water power resources are relatively remote and scattered. Nevertheless, hydro-electric works (for the production of aluminium) were established in Scotland as far back as 1896 and in the inter-war period some sizeable hydro-electric projects were completed both in Wales and in Scotland. More recently the shortage and increasing cost of coal have encouraged hydro-electric developments of outstanding importance under the auspices of the North of Scotland Hydro-Electric Board.

By the end of 1955 the Board had 22 post-war hydro-electric stations in operation and 18 were under construction. Total installed capacity of stations in operation (including 84,750 kilowatts of the pre-war Grampian scheme) was 558,795 kilowatts, with an average output of 1469 million units per annum. Hydro-electric schemes under construction had a capacity of 310,900 kilowatts and schemes in course of promotion and survey accounted for a further 418,450 kilowatts.

The constructional work carried out on the Board's hydro-electric schemes has made exacting demands on civil engineering techniques. It has involved the building of strong and secure dams and reservoirs for catchment and storage of water, the laying down of pipelines to withstand strong pressures and the driving of tunnels through difficult mountain rock and considerable road construction. Dam building has included the following examples of different designs and forms of construction: concrete gravity, massive concrete buttress, round-headed concrete buttress, diamond-headed concrete buttress, rock-fill, earth fill and pre-stressed concrete. The pre-stressing at Allt-na-Lairige (in Sutherland) was provided by groups of steel rods and cables which held the dam down to the rock.

In 1955 over 24 miles of tunnels were driven in rock. This brought the total mileage of rock tunnel driven under the Board's schemes up to 110 miles, and a further 30 miles were in hand. The mileage of roads which the Board had built, rebuilt or were under construction totalled 279 miles; of these 102 miles were public roads and the remainder were for access to the Board's works.

Atomic Energy. Britain is among leading countries in the development of atomic energy, and here civil engineering has an important part to play, entailing the exercise of special skills. The unusual size and shape of the necessary structures, the need for very elaborate safety measures for personnel and the need to avoid 'contamination' of the atomic reactor by elements which would interfere with the chain reaction present new problems.

So far, four main installations have been set up by the UK Atomic Energy Authority. At the Springfields factory, near Preston, uranium metal and uranium hexafluoride are extracted from uranium ore. At the Capenhurst factory in Cheshire, uranium is separated into its isotopes by gaseous diffusion. At Windscale, in Cumberland, plutonium is manufactured from irradiated uranium metal and refined. Adjacent to Windscale is Britain's first atomic power station–Calder Hall—In addition to the new problems mentioned above, associated with all atomic structures, each of these installations posed some special problems of its own. At Windscale, for instance, the total weight of the two atomic piles is about 60,000 tons and they are supported on a concrete raft 20,000 feet in area and 10 feet thick. The structure had to be designed on a precision basis, with exceptionally fine tolerances. Special problems had also to be tackled in the disposal of radio active effluents. At Calder Hall there have been constructed two reactor buildings, each containing a relatively large atomic pile which is enclosed in a huge concrete 'biological shield', to protect operators from nuclear radiation.

In 1955 foundations were laid for a fast reactor type of station at Dounreay in the North of Scotland. Although the reactor core is small exceptionally heavy foundations are needed for the protective shielding. This type of reactor creates more fissile material than it actually uses up.

The Central Electricity Authority's ten-year development programme for atomic power, announced in February 1955, envisages an expenditure of £300 million on the construction of 12 atomic power stations which by 1965 will be capable of generating between 1,500 and 2,000 megawatts of electricity.

HOW TO RESERVE ACCOMMODATION

Unless you reserve your berth (I Class) or Seats (II and 3rd Class long distance) in advance, you may not be sure of getting accommodation on the train you wish to travel by.

Application should be made to the Station Master of your starting station at least 3 days in advance specifying the date and train by which you intend travelling and the tickets must be bought in advance. The reservation fee leviable is 8 Annas per seat or berth.

Reservation by I and II Class from intermediate stations by Express trains can also be made similarly, but reservation ticket can be issued only after getting an advice from the Reservation Centre that the reservation has been made.

Tickets will be issued only if accommodation is available.

If the reserved seats or berths are not occupied at least 5 minutes before the booked departure of the train the reservation will be cancelled and the seat or berth given away to another.

Reservation fee is not refundable.

III Class seats are also reservable on Express and certain other important trains for long distance passengers from the train-starting stations on payment of a reservation fee of 4 Annas per seat.

Do not occupy a berth or seat reserved for another, as you are liable to be displaced at the last moment.

If you find another person occupying the berth or seat reserved for you and if he will not vacate it on demand, report it to the Guard or Station Master. They will help you.

(Inserted in the interests of Travelling Public)

CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity; they are more important than medicines.

Cleanliness prevents disease; medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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